6.0 STREAMLINED RISK EVALUATION

This section presents the Human Health Screening Evaluation (HHSE) and Ecological Screening Evaluation (ESE), which assess potential impacts on human health and ecological receptors, respectively, from exposure to chemicals in site media. The HHSE and ESE are not quantitative risk assessments, but are preliminary, semi-quantitative screening evaluations in which chemical concentrations detected in soil and surface water at the site are compared to screening values. The screening values used for comparison are based on a number of conservative (i.e., protective) assumptions which likely overestimate risks. The presence of chemicals at concentrations above the screening values does not necessarily indicate that adverse impacts are occurring; rather, it indicates that there is a potential for adverse impacts to occur and further evaluations, such as an additional site assessment or baseline human health and/or ecological risk assessments, may be warranted.

6.1 Human Health Screening Evaluation

This section presents the methods and results of the HHSE that was conducted to evaluate the potential for adverse health effects to occur from exposure to chemicals detected in soil and surface water at the site. Potential receptors and exposure pathways are described in Section 6.1.1, the conceptual site model (CSM). Section 6.1.2 describes exposure point concentrations used in the HHSE. Section 6.1.3 presents the methods and results of the screening evaluation. Toxicity briefs for the chemicals of potential concern (COPCs) at the site are presented in Section 6.1.4. HHSE data gaps are identified in Section 6.1.5. In Section 6.1.6, uncertainties of the HHSE are discussed.

6.1.1 Conceptual Site Model

Information concerning potential receptors and exposure pathways, including chemical sources and chemical constituent release mechanisms, were integrated into a CSM. The purpose of a CSM is to provide a framework for problem definition, to aid in the identification of data needs, which can then be addressed in the sampling plan, and to assist in identifying remedial actions for the site, if necessary. A CSM is typically based on information currently available but is dynamic and can change as new information becomes available for a site.

The human health CSM for the Morning Star Mine site is presented in Table 6a. Potential receptors were identified based on current and future land uses of the site. The potential sources presented in the CSM represent the suspected sources of chemical releases at the site and were identified on the basis of history and previous investigations.

6.1.1.1 Potential Receptors

The mine site is currently inactive. In the vicinity of the site, there are other inactive and abandoned mines. There are no active mine sites within a four-mile radius. The area surrounding the site is mainly undisturbed and is composed of native desert soil cover, granitic rock outcrops, and vegetation. There are no residences or schools within a four-mile radius of the site.

The site is located within the Mojave National Preserve and is managed by the National Park Service (NPS). The following receptors may be present on site currently and in the future and were included as potential receptors in the CSM:

- Park employees
- Construction workers
- Youth recreational visitors.

Although they are expected to visit the site, adult recreational visitors were not evaluated in the CSM because a youth recreational visitor would be more sensitive to site contamination and risks predicted for a youth visitor would be protective of an adult visitor.

6.1.1.2 Exposure Pathways

A complete exposure pathway is defined by the following four elements (*USEPA, 1989*):

- A source of chemical release into the environment
- An environmental medium for transport of the chemical (e.g., air, groundwater, or soil)
- A point of potential exposure for a receptor
- A route of exposure for the receptor (e.g., ingestion inhalation or dermal contact).

An exposure pathway is considered complete or potentially complete and exposure is considered possible only if all four of these elements are present.

All potential exposure pathways for the site are illustrated in Table 6a. Primary and secondary release mechanisms, retention-exposure mechanisms, and potential exposure routes are presented. The potential exists for a single medium to be affected by multiple sources and/or release mechanisms. The potential primary release mechanisms for the site are infiltration/leaching to surface and subsurface soils, and surface water runoff to surface water bodies. Potential secondary release mechanisms are leaching of subsurface soils to groundwater, deposition of airborne dust from soils, and volatilization from surface water. Once chemicals are present in surface and subsurface soils, air, surface water, and groundwater, receptors could potentially be exposed to them.

Although leaching from surface to subsurface soils and subsequent leaching to groundwater are potentially complete; these pathways are considered minor at the site. Based on historical information on the processing techniques employed at the mine and its arid climatological setting, it is unlikely that subsurface soils and groundwater have been impacted by the Morning Star mine operations. Site features where cyanide was present, the two heap leach pads and pregnant solution pond, were constructed with complex liner and solution recovery systems. The mean annual Class A pan evaporation rates in the vicinity of the mine are in excess of 120 inches per year (Met Fig. 3). Other than meteoric water that has accumulated in the open pit, surface water in the form of perennial springs or streams is not present on the site. Groundwater encountered during exploratory drilling by the former operator typically occurred below 200 feet bgs (VGC, 1994). While the potential pathway to groundwater from leaching of subsurface soils exists, the containment of solution on liners and the highly evaporative climate of the site reduce the likelihood this process occurring.

Table 6a presents the exposure pathways that are potentially complete for each receptor at the site. All receptors would be expected to directly contact chemicals in surface soils. Construction workers could come into direct contact with subsurface soils; however, because subsurface soils at the site are not likely impacted by site-related contamination; this pathway is considered insignificant. Groundwater at the site is approximately 200 feet below ground surface (bgs). At this depth, direct contact with chemicals in groundwater by potential receptors is unlikely. Also, it is assumed that groundwater has not been impacted by site-related contamination (see above). Direct contact with surface waters by potential receptors is a potentially complete exposure pathway at the site; however, this pathway is considered minor given the limited amount of time a receptor would contact surface water.

At pH levels below 9.5, there is a potential for cyanide to volatize from surface water in the form of hydrogen cyanide gas. Given that surface water pH levels at the mine range from 6.62 to 8.82 (Table 3.1), it is likely that hydrogen cyanide gas can volatize into ambient air and subsequently be inhaled by receptors. In summary, the following exposure routes are complete or potentially complete for all receptors at the site: ingestion of surface soils, dermal contact with surface soils, inhalation of airborne particulates from surface soils, and inhalation of volatiles in ambient air from surface water.

Each pathway considered complete or potentially complete for each receptor is typically evaluated in a risk assessment. The individual pathways may or may not result in levels that are of concern for potential receptors. Cumulative exposures from multiple pathways, however, are typically greater than contributions from single pathways due to potential additive effects. The combined exposure may result in potentially greater impacts to the receptor.

6.1.2 Exposure Point Concentrations

Exposure point concentrations (EPCs) represent area-wide chemical concentrations to which receptors at a site may be exposed over a period of time. According to USEPA (*1992*), the measure of exposure appropriate for a risk assessment is the average concentration of a contaminant throughout an exposure unit, or a geographic area to which humans are exposed. The premise is based on the assumption that over a long enough period of time, a receptor would contact all parts of the exposure area.

To select COPCs, individual sample concentrations were compared to screening values in the HHSE; EPCs were not calculated. This is a conservative approach because a receptor would not likely be exposed to only the maximum or any other particular detected concentration of a chemical for the full period of exposure.

6.1.3 Chemical Screening Evaluation

EPA (*1989*) recommends using a screening approach to select COPCs, which are the most prevalent and toxic chemicals at a site. The screening values used for comparison are based on a number of conservative (i.e., health-protective) assumptions that likely overestimate health risks. Generally, the presence of chemicals at concentrations below the screening values indicates that there is no significant threat to human health. However, an exceedance of a screening value does not necessarily indicate that adverse impacts to human health are occurring; rather, it indicates that there is a potential for adverse human health impacts to occur and a further evaluation is warranted.

In this section, concentrations of chemicals detected in soil and surface water were compared to screening values in order to select COPCs at each area of the site. Analytical data from previous site investigations for soil and surface water were used in the screening evaluation.

The following screening values were used for surface water:

- U.S. Environmental Protection Agency's (USEPA) Region 9 Preliminary Remediation Goals (PRGs) for tap water (*USEPA, 2000a*)
- California Department of Health Services' (DHS) Maximum Contaminant Levels (MCLs); (*DHS, 2001*)
- Lahontan Regional Water Quality Control Board (LRWQCB's) discharge requirements for the Morning Star Mine

For soil, the following screening values were used:

- Background concentrations in soil (*Bradford et al., 1996*)
- USEPA's Region 9 soil PRGs for residential and industrial receptors (*USEPA, 2000a*).

These screening values are discussed in the sections below.

<u>PRGs</u>

PRGs (*USEPA, 2000a*) are risk-based screening levels used for evaluating sites potentially impacted by chemicals. PRGs combine current USEPA toxicity values with USEPA Region 9 standard exposure factors to estimate chemical concentrations in environmental media (soil, air, and water) that are considered protective of humans over an exposure period. PRGs are chemical concentrations that correspond to fixed levels of theoretical excess risk (either a noncancer hazard quotient of 1 or a cancer risk of one-in-one-million [10^{-6}] {residential} or one-in-one-hundred-thousand [10^{-5}] {industrial}). USEPA considers a target range of one excess cancer case per million people (10^{-6}) to one excess case per 10,000 people (10^{-4}) to be "safe and protective of public health" (*56 CFR 3535*).

For surface water, PRGs for tap water were applied, which assume that residents would use water for domestic purposes (this exposure assumes receptor drinks 2 L of water per day). In developing tap water PRGs, USEPA incorporates the following exposure pathways: ingestion from drinking and inhalation of volatiles. The use of tap water PRGs in this assessment is highly conservative, given that the site is not used for residential purposes, contact with surface water by receptors is expected to be minor, and the surface water is not used as a drinking water resource.

PRGs for soil were derived by USEPA using residential or industrial land use assumptions. PRGs for soil were developed based on exposure assumptions that are more conservative than actual exposures are likely to be. For instance, a resident adult is assumed to ingest 100 milligrams (mg) of soil daily for 350 days per year for 30 years. The industrial scenario is also conservative, which assumes that workers are exposed directly to chemicals in soil 250 days per year for 25 years. The following exposure pathways are included in soil PRGs: ingestion of soil, dermal contact with soil, inhalation of soil particulates, and inhalation of volatiles. In the HHSE, soil concentrations were compared to residential and industrial PRGs. A park ranger receptor would be expected to have a similar degree of exposure to site soils as an industrial worker. A construction worker receptor would have a higher degree of contact with soil than residential or industrial receptors, but would likely also be exposed to chemicals at the site for a much shorter duration. Recreational receptors would be expected to visit the site intermittently and not continuously be exposed to chemicals in soil at the site. Accordingly, using residential and industrial PRGs in this assessment is conservative and is considered to be protective of all potential receptors at the site. Due to the remoteness of the site and absence of operational facilities, utilization of either residential or industrial PRGs does not reflect the site's low potential to cause adverse human health effects. As the Interim Measures are installed and site closure progresses, total maximum worker exposure is anticipated to be in terms of months; not the 25 year exposure duration used in developing the industrial PRGs.

Analyte-specific PRG values for water and soil are provided Table 6.1 (Surface Water) and in Table 6.2 (Soil).

<u>MCLs</u>

MCLs are drinking water standards adopted by DHS (*2001*) and USEPA under the Safe Drinking Water Act. MCLs are enforceable drinking water standards developed based on protection of human health. MCLs also incorporate technical feasibility concerns such as a chemical's detectability and treatability, as well as financial limitations. Primary MCLs have been developed for a number of chemical and radioactive contaminants. For many chemicals lacking primary MCLs, secondary MCLs have been established based on taste, odor, and appearance of drinking water. For copper and lead, which are regulated separately, action levels (ALs) have been developed by DHS and USEPA, which are primary drinking water standards and are to be met at the tap.

In the HHSE, primary MCLs were used. For silver, zinc, and pH, which lack primary MCLs, secondary MCLs were used. ALs were used for lead and copper. Similar to the use of PRGs, using MCLs in this assessment is highly conservative, given that the site is not used for residential purposes, contact with surface water by receptors is expected to be minimal, and the surface water is not used as a drinking water resource. Due to the remoteness, aridity of the site, and absence of operational facilities, utilization of primary and secondary MCLs will significantly over estimate the risk of adverse health effects. Surface water, as stream flow is an infrequent occurrence in the vicinity of the site. The source of surface water analyzed for this document was processing solution from the heap leach pads and standing water in the open pit. As the Interim Measures are installed and site closure progresses, total maximum worker exposure on site is anticipated to be in terms of months, not 25 years.

None of the water on site is potable. Consequently, using screening levels such as MCLs or PRGs, which are based on ingestion of 2 L per day, will be highly conservative (i.e. health protective).

Analyte-specific MCL values for water and soil are provided Table 6.1 (Surface Water) and in Table 6.2 (Soil).

<u>RWQCB Discharge Requirements</u>

The RWQCB, Lahontan Region, has specified discharge requirements for cyanide and WAD cyanide for the Morning Star Mine site. These values were also used in the screening evaluation for surface water.

<u>Background Concentrations</u>

Metals in soil can result from (1) naturally occurring (i.e., background) rocks and minerals, (2) anthropogenic sources (i.e., resulting from human activities, but not related to a particular site), or

(3) activities or releases from a site. USEPA (*1989*) recommends comparing site concentrations with background concentrations to identify non-site-related chemicals.

In the HHSE, background concentrations were compiled from a statewide background study (*Bradford et al., 1996*). Background concentrations of metals in soil can vary significantly with soil type. Therefore, only background data from San Bernadino County were used in the HHSE because they best reflect the geology found at the site. In the HHSE, if site concentrations were within the range of background concentrations, the chemical was not assumed to be site-related and was not selected as a COPC.

The results of screening evaluations for surface water and soil are discussed in the sections below.

6.1.3.1 Surface Water

The surface water data are presented in Table 6.1. The following inorganic chemicals were detected in surface water: total and WAD cyanide, barium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, selenium, silver, thallium, and zinc. Surface water samples were collected from three general areas of the site: the open pit mine, Pad No.1 / pregnant solution pond, and Pad No.2.

Chemicals were selected as COPCs if concentrations exceeded the PRG, MCL, or RWQCB requirement. As previously discussed, use of MCLs and PRGs, as screening values for this site is highly conservative. Therefore, even though chemicals were selected as COPCs, it is highly unlikely that the minimal exposures of the most likely receptors to these COPCs will result in adverse health impacts to these receptors. The following chemicals were selected as COPCs in surface water at each area of the site from which surface water samples were collected:

<u>Open Pit Mine</u>

- Thallium – exceeded the MCL and PRG in a sample collected from the bottom of the open pit.

Heap Leach Pad No. 1 Discharge/Pregnant Solution Pond/Pregnant Solution Pond Leak Detection System

- Total cyanide– exceeded the PRG (6.2 ug/L), MCL (200 ug/L), and LRWQCB discharge requirement (1 ug/L) in the pregnant solution pond sample.
- WAD cyanide – exceeded the PRG (6.2 ug/L) and LRWQCB discharge requirement) (.2 ug/L) in samples from the Heap Leach Pad 1 discharge, pregnant solution pond, and the pregnant solution pond leak detection system.
- Chromium – exceeded the Cal Modified tap water PRG (0.16 ug /L) in the Heap Leach Pad 1 discharge sample. However, the chromium concentrations were below the USEPA region 9 PRG (110 ug/L) and both the DHS MCL (50 ug/L) and the US EPA MCL (100 ug/L).
- Cobalt – exceeded the PRG (2200 ug/L) in samples collected in the pregnant solution pond, and the pregnant solution pond leak detection system. .
- Molybdenum – exceeded the PRG (180 ug/L) in samples from the pregnant solution pond, and the pregnant solution pond leak detection system.
- Selenium – exceeded the US EPA and DHS MCLs (50 ug/L) in one sample from the pregnant solution pond and one sample from the pregnant solution pond leak detection system. Both these samples were below the tap water PRG (180 ug/L).
- Thallium – exceeded the MCL and PRG in samples from the Heap Leach Pad 1 discharge, pregnant solution pond, and the pregnant solution pond leak detection system.

Pad No.2

- Total cyanide– exceeded the PRG (6.2 ug/L), US EPA and DHS MCLs (200 ug/L), and LRWQCB discharge requirement (1 ug/L) in all but two samples analyzed for the chemical.
- WAD cyanide – exceeded the PRG (6.2 ug/L) and LRWQCB discharge requirement (0.2 ug/L) in all samples collected from the area.
- Cadmium – exceeded the MCL (5 ug/L) but not the tap water PRG (18 ug/L) in one sample collected from the leachate collection system and one sample from the leak detection system.
- Cobalt – exceeded the PRG in two samples collected from standing water at the south side of the Pad.

- Lead – exceeded the US EPA and DHS MCL (15 ug/L) in one sample collected from the standing water at the south side of the Pad.
- Molybdenum – exceeded the PRG (180 ug/L) in all samples analyzed for the chemical in the leak detection system, and the standing water on the south and east sides of the pad.
- Thallium – exceeded the US EPA and DHS MCL (2 ug/L) and PRG (2.4 ug/L) in at least one sample in each of the four locations sample on pad 2.

6.1.3.2 Soil

Soil samples were collected from the following three areas of the site: Pad No.1/pregnant solution pond, Pad No.2, and the waste rock pile. Soil samples were collected from just below the ground surface at approximately 0.5 to 1 foot. In soil, total and WAD cyanide, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, thallium, vanadium, and zinc were detected (Table 6.2).

Chemicals with concentrations exceeding background values and PRGs (residential and/or industrial) were selected as COPCs in soil. The following chemicals were selected as COPCs in soil at each area of the site from which soil samples were collected:

Pad No.1/Pregnant solution pond

- No COPCs were selected.

Pad No.2

South Side of Pad

- Total and WAD cyanide – Concentrations exceeded the residential PRG (11mg/kg) in one of three samples collected.
- Lead –above PRGS in all three samples collected. The concentrations exceeded background (13.2-26.7 mg/kg) and the residential PRG (400 mg/kg) in two samples; and background (13.2-26.7 mg/kg), the residential PRG (400 mg/kg), and the industrial PRG (750 mg/kg) in another sample.

West End of Pad

- Lead - exceeded background (13.2-26.7 mg/kg), the residential PRG (400 mg/kg), and the industrial PRG (750 mg/kg) in the one sample collected.

East End of Pad

- Lead - exceeded background (13.2-26.7 mg/kg) and the residential PRG (400 mg/kg) in the one sample collected.

Waste Rock Pile

- Lead - exceeded background (13.2-26.7 mg/kg) and the residential PRG (400 mg/kg) in the one of two samples collected.
- Thallium - exceeded background (0.38-0.77 mk/kg) and the residential PRG (5.2 mg/kg) in one of 11 samples collected from the pad 2 area.

It is clear from these results that only lead soil levels in the Pad 2 area consistently exceeded the screening levels detailed in Table 6.2. However, of the 15 samples, only 6 exceeded screening levels, and of these 6, only 2 were above residential PRGs.

In both the pad 1 and pad 2 areas, all of the samples analyzed for Arsenic were non-detects. However, the detection limits was above the background levels. Consequently, to be conservative, Arsenic was kept as a COPC. Additional sampling, with more extensive sample cleanup, might decrease the detection limit. This would allow a definitive determination of the presence of Arsenic above or below background levels.

6.1.4 Toxicity of the COPCs

This section provides a brief toxicity assessment for each COPC at the site.

Total and WAD Cyanide

The toxicity of cyanide varies substantially depending on the form of cyanide, such as hydrogen cyanide gas or cyanide salts. Exposure to high levels of cyanide for short time periods can cause damage to the brain and heart, and can even result in coma and death. Worker exposure to low doses of cyanide can cause breathing difficulties, pain in the heart area, vomiting, blood changes, headaches, and enlargement of the thyroid gland. Due to inadequate data, EPA has not classified cyanide as a human carcinogen.

Cadmium

Human toxicity data indicate that exposure to cadmium can result in kidney disease, lung damage, and bone deficiencies. Animal data suggest that cadmium can cause liver damage, liver disease, nerve or brain damage, and high blood pressure. Cadmium is classified by EPA as a probable carcinogen based on human, occupational, epidemiological studies and studies on laboratory rats and mice. Epidemiological data indicate that workers may have an increased chance of developing lung cancer from inhalation exposure to cadmium.

Chromium (VI)

Chromium can be found in several different forms. Chromium III occurs naturally in the environment, whereas industrial processes produce chromium VI. Chromium III is an essential nutrient and an intake of 50 to 200 μg/day is recommended for adults. Inhalation exposure to high levels of chromium VI can result in nasal damage. There are inadequate data to determine the potential carcinogenicity of chromium III. Chromium VI is a known human carcinogen for the inhalation route only. Long-term inhalation exposure to chromium may result in lung cancer.

Cobalt

Cobalt is an essential element in humans, as a constituent of vitamin B12. Acute exposure to high levels of cobalt by inhalation in humans and animals results in respiratory effects, such as a significant decrease in ventilatory function, congestion, edema, and hemorrhage of the lung. Respiratory effects are also the major effects noted from chronic (long-term) exposure to cobalt by inhalation, with respiratory irritation, wheezing, asthma, pneumonia, and fibrosis noted. Cardiac effects, congestion of the liver, kidneys, and conjunctiva, and immunological effects have also been noted in humans. Chronic exposure to high levels of cobalt via ingestion has resulted in cardiovascular effects in humans, with effects including cardiogenic shock, sinus tachycardia, left ventricular failure, and an enlarged heart. Limited data are available on the carcinogenic effects of cobalt. Human studies are inconclusive regarding inhalation exposure to cobalt and cancer, and the one available oral study did not report a correlation between cobalt in the drinking water and cancer deaths. EPA has not classified cobalt for carcinogenicity.

Lead

Exposure to lead by young and unborn children may cause reduced growth and decreased mental ability. In adults, lead exposure may affect the memory and cause weakness in the extremities and anemia. Exposure to high levels of lead can cause brain and kidney damage and damage to the reproductive system in males and females. EPA classifies lead as a probable carcinogen based on animal data. Kidney tumors have developed in rats and mice exposed to large doses of lead.

Molybdenum

Exposure to high levels of ingested molybdenum may be associated with potential mineral imbalance, as seen in increased serum ceruloplasmin and urinary excretion of copper observed in human studies. Excretion of sufficient quantities of this element may put individuals at risk for the hypochromic microcytic anemia associated with a dietary copper deficiency. Laboratory animal studies also demonstrate that the effects of molybdenum on growth and melanin synthesis are more pronounced under situations where dietary copper intake is low. EPA does not classify molybdenum as a carcinogen due to inadequate human and animal data.

Selenium

Selenium is an essential nutrient. Selenium deficiencies in the body can cause heart problems, muscle pain, and damage to tissues. The recommended dietary allowance (RDA) for selenium is 55 and 70 μg/day for women and men, respectively. Selenium can be harmful at dietary levels that are 5 to 10 times greater than these amounts. Inhalation exposure to large doses of selenium by workers can cause dizziness, fatigue, and irritation of the mucous membrane. EPA has not classified selenium as to its carcinogenicity in humans due to inadequate human and animal data. Studies of laboratory animals have shown that most forms of selenium most likely do not cause cancer. EPA has classified one form, selenium sulfide, as a probable human carcinogen based on animal data.

Thallium

Exposure to large amounts of thallium for short periods of time can affect the nervous system, lung, heart, liver, and kidney. Animal data also suggest that exposure to large amounts of thallium over short periods of time can cause nervous system and heart damage and can cause death. There are no data on health effects from human exposure to small amounts of thallium for long periods. EPA does not classify thallium as a carcinogen due to inadequate human and animal data.

6.1.5 Uncertainties

Uncertainty is inherent in the risk assessment process. Because direct measurements are not available for many of the criteria upon which a risk assessment is based, conservative assumptions and methodologies are employed to eliminate the possibility of underestimating risks. The screening values used in the HHSE are based on a number of conservative (i.e., health-protective) factors that are likely lower than necessary to reasonably protect human health. The following factors contribute to the conservatism of the HHSE:

- Site concentrations were compared to residential PRGs for soil, which assume that a receptor would be in direct contact with soil for 30 years, 350 days per year. Potential receptors identified at the site were a park ranger, construction worker, and youth recreational visitor. These receptors would not be expected to have as high a degree of exposure to site soils as residents. The industrial PRGs also incorporate a number of conservative estimates, such as a 25 year, 250 days per year exposure assumption.

- Site concentrations were compared to tap water PRGs and MCLs that are based upon consumption of 2 L per day. However, the site is not used for residential purposes, contact with surface water by receptors is expected to be minor, and the surface water is not used as a drinking water resource.

- Individual detected concentrations were compared to screening values to select COPCs. This assumption is conservative given that receptors would not be exposed to the maximum or individual concentrations at the site. Rather, they would likely be exposed to an average concentration across the site.

- The screening values used in the HHSE incorporate Cal/EPA and USEPA toxicity factors, which are developed using conservative methods and tend to result in conservative risk evaluations.

6.1.6 Summary of HHSE and Recommendations

Based on the information presented above, Total cyanide, WAD cyanide, cadmium, chromium, cobalt, copper, lead, molybdenum, selenium, and thallium concentrations may be of concern to human health. A site-specific risk assessment could be conducted to assess the potential for unacceptable risks to receptors likely to come in contact with site media under realistic exposure conditions. Additional data may be needed to evaluate the form of some chemicals present (e.g., chromium III versus chromium VI) as well as the bioavailability/leachability of metals in site media. Additionally, site-specific background levels of metals in soil and/or surface water could be useful in the selection of COPCs and in differentiating between site-related and non-site-related risks. However, due to the remoteness of the mine, aridity of the site, and absence of operational facilities, few potential human receptors will visit the site. Due to the short expected exposure duration for those receptors likely to present on the site, adverse human health effects are unlikely.

6.2 Ecological Screening Evaluation

The following section presents a qualitative evaluation of potential impacts to non-human receptors as a result of exposure to chemicals detected at the site heavy metals such as lead as well as total and WAD cyanide have been detected in soil at the site. To biologically characterize the site, background information and the California Department of Fish and Game's Natural Diversity Database (CNDDB; *California Department of Fish and Game, 2001*) were reviewed to identify sensitive plants and animals that might occur on or within one mile of the site. Based on the biological characterization and site chemical data, a pathway analysis was performed to identify the potential for biota to come in contact with chemicals detected at the site. Section 6.2.1 describes the site characteristics. Section 6.2.2 describes the vegetation and wildlife present in the preserve. Potential exposure pathways for wildlife and vegetation species are described in section 6.2.3. Uncertainties pertaining to the ESE are identified in Section 6.2.4 and ESE recommendations are discussed in Section 6.2.5.

6.2.1 Site Characterization

The elevation of the mine site is approximately 4,570 above mean sea level. Local relief is highly variable. The undisturbed surrounding landscape is composed of native desert soil cover, and granitic rock outcrops. The vegetation is composed of creosote bush, various species of cacti, and desert needlegrass.

Relevant to the ecological screening assessment, the open pit and pregnant solution ponds on the site provide potential habitat for biota, and is further discussed in this assessment.

Surface water in the form of perennial springs or streams is not present on the site. Storm water from precipitation events flows in the form of sheet flow to an unnamed ephemeral wash that flows generally east and north towards the Ivanpah dry lake bed. Additionally, the stormwater drainage area for the leach pads and pregnant solution pond is approximately 17.5 acres (CCJM, 1996). Upgradient stormwater is diverted around Pad No.1 and around the pregnant solution pond. Overland sheet flow runoff from both the leach pads and the pregnant solution pond flows southeasterly toward an unnamed, ephemeral wash located approximately 0.25 miles from the site (CCJM, 1996). Offsite ephemeral drainage flows toward the Ivanpah Valley dry lakebed where it evaporates or infiltrates the soil.

Previous land use and recreation surveys have indicated that land use within the region consists primarily of livestock grazing and mineral exploration and development. Recreational use near the site is primarily on and off-road vehicle exploration (Vanderbilt Gold Corp., 1994).

6.2.2 Biological Characterization

<u>Previous Site Investigations</u>

The information in this section describing previous site investigations was obtained from the plan of operations compiled by the former operator of the site (VGC, 1994).

Vegetation - Previous site investigations have indicated that the Morning Star Mine occupies two separate substrates: rocky slopes (the mine proper) and the alluvial fans that have coalesced around the base of Cactus Hill. The rocky slopes support Barrel cactus (*Ferocactus acanthodes* var. *acanthodes*). The Barrel cactus is largely restricted to the rocky slopes and can be found all over the southern slopes of the Ivanpah Mountains both north and south of the mine.

Joshua Trees (*Yucca brevifolie*) are found on both the rocky slopes and the alluvial fans. This area is classified as Joshua Tree Woodland and exhibits a high degree of diversity. The dominant perennials are the Mojave yucca (*Yucca schidigera*) and the Staghorn cholla (*Opuntia acanthicarpa*).

The area is also a transitional zone with an overlap of the Creosote plant community at the lower elevations. In equal to or greater numbers than the Joshua Tree, is the creosote bush (*Larrea tridentata*). The brush component of this plant community is made up primarily of California

Wild-buckwheat (*Eriogonum fasciculatum*), Blackbrush (*Coleogyne ramosissima*), Cooper's Goldenbush (*Haplopappus cooperii*), Cat's-claw Acacia (*Acacia greggii*), Nevada Mormon Tea (*Ephedra nevadensi*) and Paper Bag Bush (*Salazaria mexicana*), among others. Red Brome (*Bromus rubens*), Galleta (*Hilarias jamesii*) and Abu Mashi (*Schismus barbatus*) are the common grasses to be found across the site. A previous site investigation cited that no rare, threatened or endangered plants are found at the Morning Star Mine (Vanderbilt Gold Corp., 1994).

Wildlife - The habitat surrounding the Morning Star Mine contains some of the wildlife expected within the Joshua Tree Woodland and Creosote Scrub plant communities. Food, cover, dispersion corridors, and other special habitat requirements for small animals, birds, and reptiles were found surrounding the site.

Mammals potentially occurring in this habitat community include: Blacktail Jackrabbit (*Lepus californicus*), the Desert Cottontail rabbit (*Sylvilagus auduboni*), coyote (*Canis latrans*), Desert Woodrat (*Neotoma lepida*), occasionally the Merriam Kangaroo rat (*Dipodomys merriami*), the Panamint Kangaroo rat (*Dipodomys panamintius*), and the Western Pipistrelle bat (*Pipistrellus hesperus*) can be seen (Vanderbilt Gold Corp., 1994).

Avian species potentially occurring in the vicinity of the site include the Cactus Wren (*Campylorhynchus brunneicapillus*), Black-throated Sparrow (*Amphispizza bilineata*) and Gambel's Quail (*Callipepla gambelli*). Occasional sitings of Scott's Oriole (*Icterus parisorum*), the Loggerhead Shrike (*Lanius Iudovicianus*), and the Ash-throated Flycatcher (*Myiarchuis cinerascens*) have been noted (Vanderbilt Gold Corp., 1994).

Potentially occurring reptiles include the collared lizard *(Crotaphytus collaris*) and the Mojave rattlesnake (*Crotaphytus scutalatus*). Evidence of Gila *Monster (Heloderma suspectum*) and the Desert Tortoise (*Gopherus agassizi*) have been found previously around the project site (Biotic Resources Survey, 1984, Vanderbilt Gold Corp., 1994). A second survey for the Desert Tortoise below elevation of 4000 feet and to the east of the site found one Desert tortoise and a few active burrows (Desert Tortoise Survey, 1988, Vanderbilt Gold Corp., 1994).

Recent Site Investigations

The biological characterization of the site included a review of the CNDDB to identify sensitive plants and animals that might occur on or within one mile of the site. CNDDB records for the 7.5-minute USGS Joshua quadrangle were reviewed and are presented in the CDNNB Appendix.

Vegetation - The results of the CNDDB review indicate that 21 sensitive plant species have been recorded within 1 mile of the site:

- Mojave Milkweed (*Asclepias nyctaginifolia*)
- Many-Flowered Schkuhria (*Schkuhria multiflora var. multiflora*)
- Curved-Spine Beavertail (*Opuntia curvospina*)
- Viviparous Foxtail Cactus (*Coryphantha vivipara var. rosea*)
- Charleston Sandwort (*Arenaria congesta var. charlestonensis*)
- Cima Milk-Vetch (*Astragalus cimae var. cimae*)
- Scrub Lotus (*Lotus argyraeus var. multicaulis*)
- Forked Purple Mat (*Nama dichotomum var. dichotomum*)
- Aven Nelson's Phacelia (*Phacelia anelsonii*)
- Sky-Blue Phacelia (*Phacelia coerulea*)
- Thorne's Buckwheat (*Eriogonum ericifolium var. thornei*)
- Juniper Buckwheat (*Eriogonum umbellatum var. junipornium*)
- Purple Bird's-Beak (*Cordylanthus parviflorus*)
- Nevada Onion (*Allium nevadense*)
- Red Grama (*Bouteloua trifida*)
- Tough Muhly (*Muhlenbergia arsenei*)
- Few-Flowered Muhly (*Muhlenbergia pauciflora*)
- Wooton's Lace Fern (*Cheilanthes wootoni*)
- Cliff Brake (*Pallaea truncata*)
- Cloak Fern (*Argyrochosma limitanea var. limitanea*)
- Plummer's Woodsia (*Woodsia plummerae*)

Of the 21 species, only Thorne's Buckwheat is listed as a state endangered species.

Wildlife - The results of the CNDDB review indicate that 7 sensitive wildlife species have been recorded within 1 mile of the site. These species include the Pale Big-Eared Bat (*Corynorhinus townsedii pallescens*), Nelson's Bighorn Sheep (*Ovis canadensis nelsoni*), the Desert Tortoise (*Gopherus agassizi*), Grey Vireo (*Vireo vicinior*), Virginias Warbler (*Vermivora virginiae*), Hepatic Tanager (*Piranga flava*), and the California Gray-Headed Junco (*Junco hyemalis caniceps*). Of the seven species, only the Desert Tortoise is listed as both a federal and state threatened species. In addition, the wildlife habitat represented by the area including and immediately surrounding the mine site appears to be appropriate only for the Desert Tortoise (CNDDB).

Desert Tortoise is a state and federally listed threatened species that inhabits desert scrub, desert wash, and Joshua tree habitats, and requires friable soil for burrow and nest construction. The Pale Big-Eared Bat is a California Department of Fish and Game (CDFG) species of special concern that lives in a wide variety of habitats but is most common in mesic sites and needs appropriate roosting, maternity, and hibernacula sites free from human disturbance. The Nelson's Bighorn Sheep is a species of concern which is widely distributed in the White and Chocolate Mountains in Mono and Imperial counties, respectively. The Grey Vireo is a CDFG species of special concern that inhabits dry chaparral and can be found inhabiting both chamise-dominated and juniper-artemisia habitats. The Virginias Warbler a CDFG species of special concern that is found in arid, scrubby, mixed-conifer, pinyon-juniper, and montane-chaparral environments. The Hepatic Tanager is a CDFG species of special concern that inhabits white fir-pinyon forests on desert peaks. The California Gray-Headed Junco is a CDFG species of special concern that inhabits white fir and can be found in dense pinons above 6700 feet.

6.2.3 Pathway Assessment

A pathway assessment was conducted to evaluate the potential for wildlife and plants to be exposed to chemicals detected in soil and surface water at the site. An exposure pathway is considered complete if the following four elements are present: (1) a source of chemical release to the environment, (2) an environmental medium for transport (i.e., soil, air, surface water, or groundwater), (3) a point of potential exposure, and (4) a route of exposure (i.e., ingestion, inhalation, or dermal contact). The site conceptual models, shown on Tables 6a, 6b and 6c (Risk Assessment), present the exposure pathways associated with potential terrestrial and aquatic receptors at the site, respectively.

Potential wildlife receptors are discussed above. Potential aquatic receptors are expected to be limited to aquatic invertebrates and amphibians that may be present in the ponds onsite and in offsite surface water bodies.

Several potential exposure pathways associated with ecological receptors at the site are likely complete because habitat for sensitive species is present onsite. Potentially complete soil pathways (Table 6b) include direct contact and uptake of surface and subsurface soils by plants and soil invertebrates, ingestion of subsurface soils by burrowing reptiles and mammals, direct ingestion of surface soils by reptiles, birds, and mammals, as well as exposure via ingestion of food items by reptiles, birds, and mammals. Potentially complete surface water pathways (Table 6c) include ingestion or direct contact of sediments and surface water by aquatic plants, aquatic invertebrates, amphibians, birds, and mammals and ingestion of food items by amphibians, birds, and mammals. Inhalation pathways are noted as insignificant because inhalation pathways are generally not risk driving for wildlife receptors, though the high toxicity of cyanide gas may present potential risks to wildlife. Dermal contact pathways for birds and mammals are generally not risk driving (*USEPA, 2000c*).

6.2.4 Chemical Specific Ecological Screening Assessment

Chemical specific screening values were used to evaluate potential chemicals of ecological concern (COPCs) for terrestrial and aquatic species. The following screening evaluations were conducted:

- Table 6.3 presents a comparison of maximum concentrations of COPCs in surface water to available screening values. For surface water screening, maximum concentrations were compared to USEPA Ambient Water Quality Criteria for freshwater aquatic life protection in inland surface waters (*USEPA, 2000b*).
- Table 6.4 presents screening values for plants exposed to soil compiled by Oak Ridge National Laboratory (*Efroymson et al., 1997a*).
- Table 6.5 presents screening values for soil invertebrates compiled by Oak Ridge National Laboratory (*Efroymson et al., 1997b*).
- Table 6.6 presents screening values for wildlife species. Screening values for wildlife species are generally unavailable. USEPA is currently developing ecological soil screening levels (EcoSSLs; *USEPA, 2000c*). However, this effort is not yet complete. The only detected

chemicals for which there are EcoSSLs are antimony, chromium, and cobalt. In addition to the EcoSSL guidance, non-species specific ecological screening values for soil compiled by USEPA Region IV (1999) was used as additional criteria for wildlife screening.

All of the screening levels discussed above are conservative values. Exceedance of screening values does not indicate a significant risk but rather indicates a need for further evaluation. The following summarizes the screening evaluation:

6.2.4.1 Aquatic Life Screening Evaluation

Chemicals were selected as COPCs if concentrations exceeded the USEPA Ambient Water Quality Criteria (AWQC) for protection of freshwater aquatic life in inland surface waters. The following chemicals were selected as COPCs in surface water at each area of the site from which surface water samples were collected:

<u>Open Pit Mine</u>

- Lead – exceeded the AWQC in a sample collected from the bottom of the open pit

<u>Pad No.1/Pregnant solution pond</u>

- Total cyanide– exceeded the AWQC in the external pregnant solution pond sample.
- WAD cyanide – exceeded the AWQC in samples from the external pregnant solution pond, bottom of pregnant solution pond, and the leak detection system.
- Chromium – exceeded the AWQC in the external pregnant solution pond sample.
- Copper – exceeded the AWQC in samples from the external pregnant solution pond, bottom of pregnant solution pond, and the leak detection system.
- Lead – exceeded the AWQC in the external pregnant solution pond sample.
- Mercury – exceeded the AWQC in the external pregnant solution pond sample.
- Selenium – exceeded the AWQC in samples from the bottom of the pregnant solution pond and the leak detection system

<u>Pad No.2</u>

- Total cyanide– exceeded the AWQC in all samples analyzed for the chemical.
- WAD cyanide – exceeded the AWQC in all samples analyzed for the chemical.

- Cadmium – exceeded the AWQC in samples collected from the leachate collection system and leak detection system.
- Copper – exceeded the AWQC in all samples analyzed for the chemical.
- Lead – exceeded the AWQC in samples collected from the leachate collection system and from standing water at the east sides of the Pad.
- Selenium – exceeded the AWQC in all samples analyzed for the chemical.

6.2.4.2 Plant Screening Evaluation

Chemicals with concentrations exceeding background values (see Section 6.1.3) <u>and</u> Oak Ridge National Laboratory Plant Screening Levels were selected as COPCs in soil. The following chemicals were selected as COPCs in soil at each area of the site from which soil samples were collected (Table 6.4):

<u>Pad No.1/Pregnant solution pond</u>

- Copper – exceeded background and plant screening levels in two samples.
- Lead – exceeded background and plant screening levels in three samples.
- Molybdenum - exceeded background and plant screening levels in three samples.

<u>Pad No.2</u>

South Side of Pad

- Copper – exceeded background and plant screening levels in three samples.
- Lead – exceeded background and plant screening levels in two samples.
- Molybdenum - exceeded background and plant screening levels in two samples.

20 feet south of slope failure

- Lead – exceeded background and plant screening levels in one sample.
- Molybdenum - exceeded background and plant screening levels in one sample.

West end of Pad

- Copper – exceeded background and plant screening levels in one sample.
- Lead – exceeded background and plant screening levels in two samples.
- Molybdenum - exceeded background and plant screening levels in two samples.

<u>Waste Rock Pile</u>

- Copper – exceeded background and plant screening levels in one sample.

- Lead – exceeded background and plant screening levels in three samples.
- Molybdenum - exceeded background and plant screening levels in two samples.
- Thallium - exceeded background and plant screening levels in one sample.

6.2.4.3 Soil Invertebrate Screening Evaluation

Chemicals with concentrations exceeding background values and Oak Ridge National Laboratory soil invertebrate screening levels were selected as COPCs in soil. The following chemicals were selected as COPCs in soil at each area of the site from which soil samples were collected (Table 6.5):

<u>Pad No.1/Pregnant solution pond</u>

- Copper – exceeded background and plant screening levels in two samples.

<u>Pad No.2</u>

South Side of Pad

- Copper – exceeded background and plant screening levels in three samples.
- Lead – exceeded background and plant screening levels in two samples.

20 feet south of slope failure

- No chemicals exceeded background and plant screening levels.

West end of Pad

- Copper – exceeded background and plant screening levels in two samples.
- Lead – exceeded background and plant screening levels in two samples.

<u>Waste Rock Pile</u>

- Copper – exceeded background and plant screening levels in one sample.
- Lead – exceeded background and plant screening levels in one sample.

6.2.4.4 Wildlife Screening Evaluation

Chemicals with concentrations exceeding background values <u>and</u> EcoSSL values were selected as COPCs in soil. Additionally, since few EcoSSLs (USEPA, 2000d) exist, additional screening levels were taken from USEPA Region IV ecological screening values for soil (1999). It should be noted these values are inclusive of wildlife, invertebrates, and plants, so are most likely overly conservative. The following chemicals were selected as COPCs in soil at each area of the site from which soil samples were collected (Table 6.6):

Pad No.1/Pregnant solution pond

- WAD cyanide – exceeded screening levels in two samples.
- Cadmium – exceeded screening levels in one sample.
- Copper – exceeded screening levels in two samples.
- Lead – exceeded screening levels in three samples.
- Molybdenum – exceeded screening levels in three samples.

Pad No.2

South Side of Pad

- Total cyanide– exceeded screening levels in three samples.
- WAD cyanide – exceeded screening levels in one sample.
- Copper – exceeded screening levels in three samples.
- Lead – exceeded screening levels in three samples.
- Molybdenum – exceeded screening levels in two samples.

20 feet south of slope failure

- Lead – exceeded screening levels in one sample.
- Molybdenum – exceeded screening levels in one sample.

West end of Pad

- Total cyanide– exceeded screening levels in two samples.
- Cadmium – exceeded screening levels in two samples.
- Copper – exceeded screening levels in two samples.
- Lead – exceeded screening levels in two samples.
- Molybdenum – exceeded screening levels in two samples.

Waste Rock Pile

- Cadmium – exceeded screening levels in two samples.
- Copper – exceeded screening levels in one sample.
- Lead – exceeded screening levels in three samples.
- Molybdenum – exceeded screening levels in two samples.
- Thallium - exceeded screening levels in one sample.

6.2.4 Uncertainties

Uncertainty is inherent in the risk assessment process. The methods and screening values used in the ESE are based on a number of conservative assumptions that likely overestimate potential risks. The following factors contribute to the conservatism of the ESE:

- Site concentrations from each location were compared to conservative screening levels when receptors will be exposed to a large area, including areas offsite that are not contaminated.
- Chemicals were assumed to be 100 percent bioavailable and the most toxic form was assumed to be present.
- Species-specific evaluations were not conducted and site-specific exposure factors were not incorporated.

6.2.5 Summary of ESE and Recommendations

Based on the information presented above, Total cyanide, WAD cyanide, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, and thallium concentrations may be of concern to ecological receptors. A site-specific risk assessment could be conducted to assess the potential for unacceptable risks to receptors likely to come in contact with site media under realistic exposure conditions. As such, an ecological survey could determine the types of species likely to be most highly exposed to site media as well as the presence of special-status species within the site area and potential usages of the site by ecological receptors (i.e., nesting versus foraging). Additional data may be needed to evaluate the form of some chemicals present (e.g., chromium III versus chromium VI) as well as the bioavailability/leachability of metals in site media. In particular, acid volatile sulfide/simultaneously extracted metal (AVS/SEM) analyses are useful in assessing the bioavailability and potential toxicity of metals from mining waste. Additionally, site-specific background levels of metals in soil and/or surface water could be useful in the selection of COPCs and in differentiating between site-related and non-site-related risks. Additional sampling may be needed, including analysis of soil from ephemeral drainages to the southeast and southwest of the mine facilities, to more clearly define pre-existing background conditions.